A Study to Co-Relate the Foot Posture Index, H/M Ratio and Spatial Gait Parameters in Post-Stroke Patients with Ankle Planter-Flexor(Calf) Spasticity- An Observational Study

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Abstract

Background: Stroke is one of the most commonly occurring disease which leads to hemiparesis along with other symptoms like spasticity, sensory disturbances etc. considered to be a part of positive signs of upper motor neuron (UMN) syndrome. Spasticity is a common disorder in patients with injury of the brain and spinal cord.

Aim: The aim of the present study was to corelate the foot posture index, H/M ratio and spatial gait parameters in the assessment of poststroke patients with ankle planter-flexor spasticity.

Methodology: It was an observational study which consisted of 32 chronic stroke patients. Both male and female with age group 45-70 years and stroke duration more than 3 months were included in the study. Spasticity was assessed using H/M ratio, foot posture was assessed by Foot Posture Index (FPI) and Step length and Stride length were taken.

Result: Statistical analysis was done using SPSS 20 for windows. The correlation between Hmax/Mmax ratio, FPI, step length and Stride length were evaluated using Spearman's correlation coefficient test. It was suggestive of strong negative correlation between FPI and Hmax/Mmax ratio, weak negative correlation between step length Hmax/Mmax ratio, strong negative co-relation between stride length and H/M ratio, moderate positive co-relation between Foot Posture Index (FPI) and step length and strong positive co-relation between FPI and stride length. ($p<0.05$)

Conclusion: From the present study it can be concluded that there is co-relation between Spasticity, Foot posture and Gait parameters in planter-flexor spasticity in post-stroke patients. It can also be concluded that Hmax/Mmax ratio and FPI are needed to be assessed in every post stroke patient as it has influence on Gait parameters such as step length and stride length.

***Keywords**: Stoke, Foot Posture Index, Gait, Step Length, Stride Length, H-reflex, H/m ratio.*

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Introduction

Stroke is defined as sudden loss of neurological functions resulting from ischemic or hemorrhagic lesions in the brain, which lasts more than 24 hours. It is caused by interruption of blood flow to the brain usually by atherosclerotic plaques that occur at certain sites of predilection. These sites generally include bifurcations, constrictions, dilation, or angulations of arteries.[1]

Stroke is defined by World Health Organization (WHO) as a clinical syndrome characterized by rapidly developing clinical symptoms and/or signs of focal and at times global loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin.[2, 3]

Similarly, the incidence rate increases from 27 to 34/100,000 in the 35 to 44 years age groups to 822 to 1116/100,000 in the above 75 years age group.[4]

Spasticity (hypertonicity) is a term, which was introduced to describe the velocity-sensitive increased resistance to a limb movement in subjects with lesions of descending corticospinal pathways.[5] it is considered to be a part of positive signs of upper motor neuron (UMN) syndrome.[6]

The reflex hyper excitability develops over several months following the primary lesion and involves adaptation in the spinal neuronal circuitries caudal to the lesion.[5] However, the onset of spasticity is highly variable and can occur in the short-, medium- or long-term post-stroke period.[6] In post-stroke patients, the prevalence of spasticity has been reported to be 19% after 3 months and 20% after 18 months.[7] Another study observed that spasticity primarily affects the elbow (79%), the wrist (66%) and the ankle (66%).

Other significant consequences of spasticity are tightness in muscles which may result in pain and contracture. These changes contribute as a biomechanical component, in addition to the neural components, to the disability resulting from spasticity.[8]

H-reflex was described by Johanan Hoffmann in 1918, hence called H-reflex.[9] It is a mono synaptic reflex elicited by submaximal stimulation of the nerve. It is analogous to the mechanically induced spinal stretch reflex. The H-wave is a good indicator of the strength and distribution of the stimulus input from muscle spindle to the motor neuron pool, which lies at the site of the anterior horn of the spinal cord[9] and hence is an objective method for the measurement of spasticity.

The FPI-6 is a novel method of rating foot posture using set criteria and a simple scale. The FPI is a diagnostic tool devised to provide objective numerical values that reflect the condition of the foot, whether the foot is pronated, supinated, or neutral. When the sum of each measured value is a high positive number, the foot is considered to be pronated, while the lower the negative number of the sum is, the more supinated the foot.[10]

Increased muscle tone causes spastic muscles to resist stretch and to remain shortened for longer duration. Prolonged muscle shortening leads to joint deformation and changes in intrinsic properties of soft tissue and muscle fibres, which in turn restricts range of motion and collectively leads in volition movements and activity limitations. [11] Also, due to spasticity, change in biomechanical comsponent can occur which may lead to disability. [12] Uncontrolled spasticity leads to muscular contracture, leading to abnormal posture; therefore, it has high clinical significance to be able to evaluate the influence of spasticity on motor performance.[12] Spasticity in planter-flexors may leads to impairment in gait.[9] Thus, there is a need to study spasticity and correlate them with biomechanical changes and gait.

Aims and Objectives

Aim:

- The aim of the study is to co-relate the foot posture index, H/M ratio and spatial gait parameters in the assessment of post-stroke patients with ankle planter-flexor spasticity.

Objectives:

- To assess spasticity by H/M ratio in post stroke patients.
- To asses foot posture by Foot Posture Index in post stroke patients.
- To assess spatial gait parameters in post stroke patients.
- To find co-relation among all the above factors in post-stroke patients..

Hypothesis:

- **Null Hypothesis**: There will be no correlation between H/M ratio, Foot posture index and Spatial gait parameters in Planter-flexor spasticity of chronic stroke patients.

- **Experimental Hypothesis**: : There will be significant correlation between H/M ratio, Foot posture index and Spatial gait parameters in Planter-flexor spasticity of chronic stroke patients.

Method:

- Study Setting: Shri K.K. Sheth Physiotherapy College, Rajkot.
- Source of data: Various physiotherapy centers in Rajkot.
- Study population: Ambulatory stroke patients.
- Sample size: 32 patients.
- Sampling method: Convenient sampling.
- Study Design: A co-relational study.
- Study Duration: One-time study.

Materials And Tools

- Pen
- Paper
- Record and Data collection sheet (Annexure 10.2 and 10.3)
- Consent form (Annexure 10.1)
- Chair
- Ink
- White Paper
- NCV machine (RMS EMG EP MK-II, Version1.1)
- Micropore
- Plinth

Methodology

Ethical Approval regarding the methodology was taken from Ethical committee before starting the study.

A brief assessment was taken to include or exclude the patient in the study.

Inclusion criteria:

- Patients having Stroke.
- Age: Between 45 and 65 years of age.
- Gender: Male as well as Female.
- Type of Stroke: Ischemic as well as Hemorrhagic type of stroke.
- Post-stoke period: 3 months to 2 years.
- Patient able to ambulate independently with or without assistive aid.
- Modified Ashworth Scale for planter-flexors: Grade 2 or more.
- Subjects having unilateral hemi-paresis with Brunnstrom recovery stage 2-4.
- Ability to understand and follow instructions.

Exclusion criteria:

- Subjects having language, visual, perceptual or cognitive impairments.
- Any type of recent lower limb fracture.
- Any type of recent non-paretic lower limb fracture.
- Uncooperative patient.
- Subjects having associated other neurological disorder.

Procedure:

After proper explanation about the purpose and procedure of the study, patients who were willing to participate in the study were requested to sign a written consent form. The selection of patients was done by convenient sampling.

The data measured were recorded in the data collection form which included name, age, gender, dominance, side involved, post stroke duration and Brunnstrom stage of recovery for the upper extremity. The study included evaluation of foot posture by FPI, spasticity by H/M ratio and spatial gait parameters.

For FPI patient had to assume stance position with double limb support. Then patient was asked to stand

still, with arms by their side and looking straight ahead. Components of FPI were: Talar head palpation, Supra and infra lateral malleolar curvature, calcaneal frontal plane position, Bulging in the region of talo-navicular joint, Height and congruence of the medial longitudinal arch and Abduction/ adduction of the forefoot on the rearfoot.

Each component of FPI was taken and final score was obtained from data.

Next, the H/M ratio will be taken for spastic calf muscle.

Position: Prone lying

Recording:

- Active Electrode: Distal Edge of Calf Muscle
- Reference Electrode: Achilles Tendon.

Stimulation -

- Square Wave pulse of 1 ms duration

Instrumentation Parameters for motor nerve conduction study:

- Sensitivity: 200-500
- Filter setting: 5hz- 3 KHz

Instrumentation Parameters for H-reflex measurement:

- Sweep speed: 10ms/div
- Sensitivity: 200-500 μv/div
- Filter setting: 3 KHz [13]

Figure 1: H/M ratio Measurement

Gait parameters- Step length and stride length were assessed as follows:

- Patients were instructed to step on an inkpad and were asked to walk on the paper roll.
- A paper of 8 m length was divided into a 5 m walkway, with 1.5 m area left at each end to start and finish lines.
- The footprints from the sole of the feet were produced on the paper as the patients walks from one end of the walkway to the other. [14]

Result

The patients' age wise distribution and Mean for Age are presented in Table 1 and Table 2 respectively.

Table 1: Patients' age wise distribution

Age Group (Years)	No of Stroke Subjects	
	Number	%
45-50	8	25
51-55	4	12.5
56-60	13	40.625
61-65	4	12.5
66-70	3	9.375
Total	32	

Table 2: Co-relation of FPI with H/M ratio, Step Length and Stride Length

Co-relation of FPI with H/M ratio, Step Length and Stride Length				
	Variables	H/M ratio	Step Length	Stride Length
FPI	r value	-0.692	0.431	0.523
	p value	0.01	0.05	0.01

Table 3: Co-relation of H/M ratio with Step Length and Stride Length

Co-relation of H/M ratio with Step Length and Stride Length			
	Variables	Step Length	Stride Length
H/M ratio	r value	-0.257	-0.513
	p value	0.05	0.03

The above table (1) displays the statistics of age distribution of the 32 stroke patients. Among the 32 stroke patients, the mean + SD of age of 32 stroke subjects was 56.5625 + 6.495 years.

Spearman correlation coefficient (rs) between FPI and H/M ratio is -.692 with p = .01. Above table (2) shows strong negative co-relation between FPI and H/M ratio.

Spearman correlation coefficient (rs) between FPI and Step Length is .431 with p =0.05. Above table (2) shows moderately positive co-relation between FPI and Step Length.

Spearman correlation coefficient (rs) between FPI and Stride Length is .523 with p= .01. Above table (2) shows strong positive co-relation between FPI and Stride Length.

Spearman correlation coefficient (rs) between H/M ratio and Stride Length is -.513 with p = .03. Above table (3) shows strong negative co-relation between H/M ratio

and Stride Length.

Spearman correlation coefficient (rs) between H/M ratio and Step Length is -.257 with p = .005. Above table (3) shows weak negative co-relation between H/M ratio and Step Length.

Discussion

Thus, Null hypothesis can be rejected and Experimental hypothesis is accepted as There is co-relation between H/M ratio, Foot posture Index and Gait parameters in assessment of planter-flexor spasticity in the patients with stroke.

In this study it was found that there is strong negative co-relation between FPI and H/M ratio, weak negative co-relation between H/M ratio and Step length, strong negative co- relation between H/M ration and Stride length, moderate positive co-relation between FPI and Step length and strong positive co-relation between FPI and Stride length.

A study by Wissel et al. showed that 25% of patients with stroke suffer from spasticity within the first 6 weeks of the event.[5]

A study by Given JD et al. reported that the muscles around the ankle joints easily develop changes in their mechanical property because they have more type I muscle fibers and connective tissue than other muscles. Owing to the characteristics of the ankle joints, stroke patients are known to be more likely to have increased spasticity and shortened fascia of the gastrocnemius on the paretic side, producing a reduced range of motion in dorsiflexion in the ankle joints. Such changes induce incorrect transmission of somatesthesia from the joint or the muscle receptors or motor response, accompanied by inappropriate ankle strategy, causing difficulty in balance control. [15]

From this study it was found that FPI and H/M ratio have strong negative co-relation suggesting more supinated foot with increased spasticity. This is supported by Ji-won Park et al (2011) who studied foot abnormalities of post stroke patients by comparing FPI and co- relating it to Spasticity. The study concluded that foot posture is related to stroke impairments, stroke patients with more severe spasticity have more severe foot abnormalities as supinated foot.

Additionally, from the result obtained it can be said that Stride length is more strongly co-related to H/M ratio and FPI as compared to Step Length. This can be supported by Pei- YiLin et al.(2006) who studied The Relation Between Ankle Impairments and Gait Velocity and Symmetry in People With Stroke and concluded that gait velocity and temporal asymmetry are mainly affected by the dorsiflexors strength, whereas dynamic spasticity of planter-flexors influenced the degree of spatial gait asymmetry in our patients who were able to walk outdoors.[16]

Also, due to spasticity changes in biomechanical component can occur which may lead to disability. Uncontrolled Spasticity leads to muscle contracture, leading to abnormal posture. This is supported by Kwah LK et al, who studied passive mechanical properties of Gastrocnemius muscle of people with ankle contracture after stroke and concluded that people with ankle contracture after stroke have shorter gastrocnemius muscle-tendon units and muscle fascicles than control participants at high tension.[17]

Conclusion

From the present study it can be concluded that there is co-relation between Spasticity, Foot posture and Gait parameters in planter-flexor spasticity in post-stroke patients.

It can also be concluded that Hmax/Mmax ratio and FPI are needed to be assessed in every post stroke patient as it has influence on Gait parameters such as step length and stride length.

This study also concludes that supinated foot posture is dominant in post stroke patients with planter-flexor spasticity.

Limitations

- Neither therapist nor the subjects were blinded to the study
- Room temperature could not be controlled.
- Type and site of the lesion was not considered.

Furthur Recommendation

- Study can be carried out specifically on patients

with anterior cerebral artery affection in which lower limb involvement is more prominent.

- Study can be conducted by assessing spasticity during various balance task instead of it taken at rest.

- This study can be done by taking different clinical and electrophysiological parameters to assess spasticity.

Source of Funding:

- No Funding was required for this study.

Conflict of Interest:

- The study did not have any conflict of interest.

Ethical Clearance: Ethical clearance was taken from Saurashtra University Ethical Committee.

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